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General Report Session No. 4: Case Histories Man-Made Vibrations

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Case Histories Man-Made Vibrations

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GENERAL REMARKS

There are eight papers in this session dealing with various aspects of man made vibrations such as due to operation of a machine, construction operations, traffic movement, and remedial measures against vibrations. These papers can generally be placed into the following categories:

* Prediction an performance of machine foundations.
* Traffic vibrations.
* Construction vibrations.
* Diagnostics, vibration isolation , and other remedial measures.

Some papers are broad based and cover more than one aspect.

PREDICTION and PERFORMANCE OF MACHINE FOUNDATIONS

There are two papers on this topic. The paper by Slabbert , Lee and Bohinsky (1993) presents a comparison of calculated and observed vibrations of the foundations of a paper making machine. The vibration response of a typical paper machine depends upon the machine frame , the foundation , and the soil properties. All these factors alongwith soil-structure interaction effects must be accounted for in any realistic design. The particular paper machine considered by Slabbert, et al was supported on 148 piles. Force - response analysis was conducted using STRUDL (ICES - STRUDL, 1976). Field measurements of the vibration amplitudes were made one year after the machine had been in operation. The observed vibration amplitudes were found to be smaller than the predicted values. No explanation has been provided by the auhors of the paper for the difference between the measured and calculated response. Slabbert et al have not furnished adequate information on the method of determining the soil properties. The values of pertinent soil properties adopted for analysis have also not been given. The details on soil properties, foundation and unbalanced forces due to machine operation would have been of great interest.

Puri and Das (1993) conducted vibration tests on two concrete blocks 1.0 m x 1.0 m x 1.0 m high and 1.5 m x .75 m x .7 m high. The natural frequencies and amplitudes in different modes of vibration were measured. The dynamic soil properties were determined by conducing in-situ and laboratory tests. The vibration response of the blocks was calculated by the linear spring method (Barkan, 1960), and also by the elastic half space method (Das, 1992; Prakash and Puri, 1988; Richart, Hall and Woods, 1970). Puri and Das have presented a comparison of the observed and predicted response of the rigid foundation blocks. It was observed that the calculated (undamped) natural frequencies by the linear spring method as well by the elastic half space method were close to the observed natural frequencies. The calculated vibration amplitudes did not show a reasonable match with the observed values. The comparison presented is based on a limited data and does justify any general conclusions. However , it seems that some refinement in estimating geometrical damping in soils is needed.

TRAFFIC VIBRATIONS

This topic has two papers. Long (1993) has presented two case studies dealing with impact of traffic vibrations. In one of the case studies, the effect of traffic vibrations on performance of a sensitive telescope in Fernbank Science Center, Atlanta, was assessed. The study was necessitated due to a proposed highway about 300 m away from the telescope building. The second case study deals with impact of traffic movement on a historical building namely, the Rhodes Hall in Atlanta due to a proposed highway ramp only about 30 m away. A three step approach involving (i) characterization of traffic vibrations, (ii) defining existing level of vibrations at the structure , and (iii) estimation of vibration levels due to the proposed highway (or highway ramp) was followed in arriving at acceptable engineering solutions for each specific problem. Particle velocity was used as a criteria for damage assessment. Vibration characteristics were defined by measuring particle velocities at various distances from highways. The effect of significant topographic features on vibration attenuation was also monitored. The measured data was used to determine empirical vibration attenuation relationships. Existing vibration levels were similarly measured.

Using the empirical vibration attenuation relationships obtained during the study, the vibration level at Fernbank Science center due to a single car at 275 m was estimated as 0.006 x 10 mm / s. The existing vibration level is only 0.0018 mm / sec. The existing vibration level produces an image distortion of about 0.2

percent. The higher level of vibrations due movement of trucks on proposed highway could increase the image distortion to about 8 percent. A topographic barrier to reduce the vibration levels was also considered. it was found that even the largest practical topographic barrier will not be adequate to bring down the estimated vibration levels to acceptable values. The proposed highway was not built. The estimated vibration levels at Rhodes Hall due movement of traffic on the proposed ramp ranged from 0.1 to 0.3 mm /s. The existing vibration levels for this structure range from 0.03 to 0.1 mm. for steady traffic. The proposed ramp was relocated about 50 m away from Rhodes Hall. The ramp was supported on pillars to further minimize the transmission of vibrations. Both these case studies proved helpful in avoiding post construction vibration problems.

Bencat (19930 has presented an analytical model for determining the spectral density of ground vibrations as a function of distance from highway and rail road tracks. The proposed model takes into account the road roughness or irregularities in the rail head, vehicle characteristics, and frequency response function of the ground. The soil medium was modelled as a visco-elastic half space. Random process theory has been used to develop the response spectrum of vibrations at any specified point. The results of the analytical model were compared with observed data near a busy road. The predicted ground vibration spectrum and the observed data in this particular case showed a good match.

CONSTRUCTION VIBRATIONS

There is one paper on this topic. Lewis (1993) has discussed important information on vibrations due to pile driving. The paper presents results of vibrations measurements at seven sites where various piles and pile driving hammers were used. Particle velocity , ground settlements and heave were measured at varying distances from the pile driving location. Based on the observed data , use of equation (1) is recommended for estimation of peak particle velocities due to pile driving.

$$V = K\ (D/\ E)^{-n} \qquad (1)$$

where V = peak particle velocity , (in / s)
K = intercept , (in /s)
D = distance (ft)
E = hammer energy (ft-lb), and
n = attenuation rate.

Lewis (1993) has also reported a case history dealing with vibrations due to driving of 14 in square, precast , prestressed concrete piles. The piles were driven about 3,200 ft from an existing sensitive structure.The observed peak particle velocities ware found in good agreement with those estimated from equation (1). The settlement and heave due to pile driving were also measured. The maximum settlement was about 3 in., and maximum heave was about 0.5 inch. Settlement and heave were generally confined to a distance equal to the length of the pile.

DIAGNOSTICS, VIBRATION ISOLATION AND OTHER REMEDIAL MEASURES

There are three papers in this topic. Svinkin (1993) has presented several case histories covering machine foundations and seismic effect of manmade vibrations. The case histories deal with determination of the cause of excessive vibrations and rectification of the problem. Two fine cone crushers suddenly developed excessive vibrations. The cause of vibrations was traced to change in behavior of underlying soil due to increase in water content due to seepage from the coal processing plant. An exhaust fan was found to vibrate excessively due to increased unbalance. In another case study reported by Svinkin, suspended vibration isolators were used to effectively decrease vibrations of a cone crusher and vibrations transmitted to the foundation. Based on observations on the performance of the foundation of a press drop hammer, Svinkin has suggested that the shape and duration of the loading pulse due to impact affects the response amplitude of the foundation. A simple equation has been given for calculation of vibration amplitude of hammer foundation. Other case studies presented in the paper by Svinkin deal with location of sensitive equipment near a horizontal compressor, driving of piles near an existing structure , and foundation settlements below a molding machine.

Gao (1993) has presented the case history of the design of a vibration isolation system for a anechoic chamber. An economic design was achieved by using a combination of a pile barrier surrounding the facility , and sand cushion below the base. Model tests were conducted to assess the effectiveness of such an isolation system. The observed response from the model tests supported the concept of using the combined isolation system.

Bodare and Erlingsson (1993) analyzed the vibration response of the Soccer Stadium in the city of Gothenburg, Sweden, to determine the cause of excessive and detrimental vibrations experienced by this structure during two previous rock concerts in 1985. The cause of excessive vibrations was traced to resonance of soil layers below the structure. No remedial measure have presented in the paper. This case history clearly brings out the role played by the underlying soil in determining the vibration response in certain situations.

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